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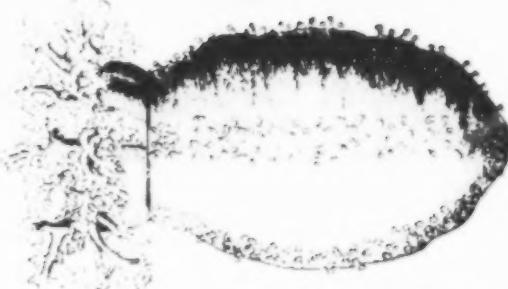
Science

Sciences

Maritimes Region

Canadian Science Advisory Secretariat
Science Advisory Report 2009/014

SOUTHWEST NEW BRUNSWICK SEA CUCUMBER (*CUCUMARIA FRONDOSA*) EXPLORATORY FISHERY ASSESSMENT



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Figure 1. Location of sea cucumber fishing zones in southwest New Brunswick.

Context

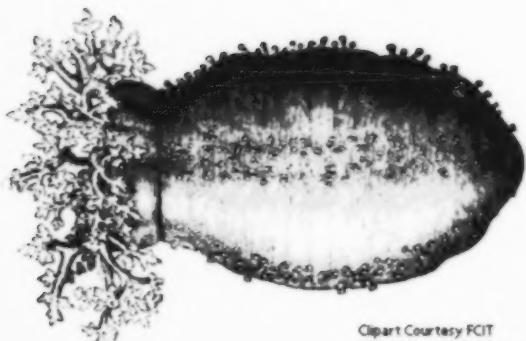
The southwest New Brunswick (SWNB) developmental sea cucumber fishery (Figure 1) has evolved since 1999 to a Stage II Exploratory fishery under the New Emerging Fisheries Policy with a recent five year average in landings of approximately 1200 t by two licence holders. A science review was requested of the sustainability and ecosystem effects of this fishery. Specifically, DFO Maritimes Fisheries and Aquaculture Management asked Science, Oceans, Habitat, and Species at Risk, "What are the potential ecosystem (stock, habitat, and by-catch) impacts of the harvest of 1000-1300 t of sea cucumber in SWNB within the identified areas of recent fishing? Characterise and provide quantitative and/or qualitative information of the relative risk to the stock, habitat and by-catch from this harvest?"

This is the first assessment of the Stage II Exploratory sea cucumber fishery in this area, though DFO Science advice was provided on this fishery in 2006 before it moved from Stage I Experimental to Stage II Exploratory (DFO 2006a). In addition, a science workshop on sea cucumber was held at the Bedford Institute of Oceanography on 17-18 June 2008.

SUMMARY

- There is very limited information on life history and stock structure of sea cucumber in the Maritimes Region. Sustainable exploitation rates and other reference points are unknown, as are the consequences of removals on ecosystem structure and function.

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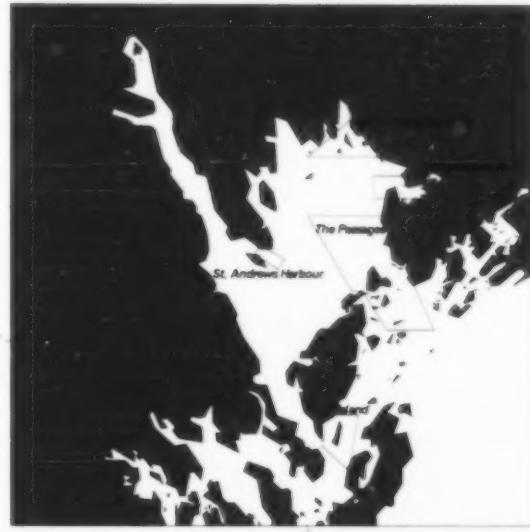


Figure 1. Location of sea cucumber fishing zones in southwest New Brunswick.

Context

The southwest New Brunswick (SWNB) developmental sea cucumber fishery (Figure 1) has evolved since 1999 to a Stage II Exploratory fishery under the New Emerging Fisheries Policy with a recent five year average in landings of approximately 1200 t by two licence holders. A science review was requested of the sustainability and ecosystem effects of this fishery. Specifically, DFO Maritimes Fisheries and Aquaculture Management asked Science, Oceans, Habitat, and Species at Risk: "What are the potential ecosystem (stock, habitat, and by-catch) impacts of the harvest of 1000-1300 t of sea cucumber in SWNB within the identified areas of recent fishing? Characterise and provide quantitative and/or qualitative information of the relative risk to the stock, habitat and by-catch from this harvest."

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SUMMARY

- There is very limited information on life history and stock structure of sea cucumber in the Maritimes Region. Sustainable exploitation rates and other reference points are unknown, as are the consequences of removals on ecosystem structure and function.

- Since 1999, more than 80% of the catch and 90% of the fishing effort was in a single fishing zone known as 'The Passages'.
- Landings increased to a peak of approximately 1600 t in 2005 and have since remained around 1100 t, which may be a function of specified fishing zones and an overall Total Allowable Catch (TAC) of 1370 t being implemented prior to the 2006 fishing season.
- Effort peaked in 2005 and has remained at lower levels during 2006-2008.
- Catch rates peaked at 4877 kg/hr in 2002 and remained similar to the long term average of 4292 kg/hr in 2007 and 2008. While catch rates have been maintained, there are uncertainties in whether catch rates in this fishery are reflective of population abundance.
- A survey in 2004 revealed that large aggregations of sea cucumbers were relatively localized with highest catches found in the northern area of Deer Island where the majority of the 2000-2004 fishing effort was directed. Because of the patchy nature of sea cucumber distribution and the lack of a systematic survey across the fishing area, it is not possible to establish a total population abundance estimate at this time.
- There was an indication of a decrease in the size of animals landed over time, although the significance of these results has not been established and additional investigation is warranted. If the size of animals landed has decreased over time, this would result in an increase in the exploitation rate associated with the TAC of 1370 t.
- The predominant by-catch species in the SWNB sea cucumber fishery was sea urchin with catches estimated at 34 t during 2008. By comparison, 1028 t of sea urchin was landed in Lobster Fishing Area (LFA) 36 during the directed fishery in 2007-2008. The sea cucumber fishery returns all species other than sea cucumber to the water, although survival of by-catch has not been evaluated for this fishery. At-sea observers provided more detailed descriptions of by-catch than recorded in Sea Cucumber Science logs and continued at-sea observer coverage is recommended.
- The environment in which the SWNB sea cucumber fishery is conducted is considered to be productive and diverse, with very patchy distribution of benthic organisms and features. Immediate, localized impacts of the sea cucumber fishing gear on benthic habitat were observed (e.g., disturbance of periphyton layer), but the longer-term community implications and rates of recovery are not known and are worthy of further investigation.
- Risks of habitat impacts within the current fishing areas could be reduced by investigating the location/extent of any particularly sensitive habitat features and investigating the rates of recovery for known habitat types within these areas.
- Given the number of uncertainties associated with this fishery, a cautious approach is advised.

INTRODUCTION

Biology

The sea cucumber (*Cucumaria frondosa*) harvested in SWNB is small and thin-walled relative to other sea cucumber species commonly harvested elsewhere. Adults attach to the bottom using

tube feet, filter feed plankton from the water column, and are thought to exhibit low rates of movement. The eggs and larvae of sea cucumber are pelagic. There is very limited information on the life history characteristics of *C. frondosa* in the Maritimes Region. Much of our understanding of this species comes from research in other areas, particularly the St. Lawrence estuary. While some of this information will be applicable to SWNB, site-specific verification is required. For example, *C. frondosa* in Passamaquoddy Bay spawns each spring in May or June, which is similar to the timing of spawning (late spring/early summer) in the St. Lawrence estuary. Other life history characteristics of interest include: growth rates, age at maturity, size at maturity, recruitment, and natural mortality.

Growth rates for *C. frondosa* in SWNB have not been determined. However, in the St. Lawrence estuary, the maximum size after five years was 10.7 cm at 20 m depth and less than 5 cm at shallower depths. These rates are lower than have been reported for other sea cucumber species. Studies in the St. Lawrence estuary indicated that growth of *C. frondosa* was mainly influenced by environmental conditions, meaning wide application of growth estimates from different areas is not appropriate.

Age at maturity for *C. frondosa* in SWNB has not been determined. However, in the St. Lawrence estuary, the age at maturity was found to be about five years old at 20 m depth. Individuals observed at shallower depths did not reach maturity within a 5 year timeframe. Age at maturity of *C. frondosa* is comparable to some other sea cucumber species (*Parastichopus californicus*, *Holothuria fuscogilva*, and *Isostichopus fuscus*), but is also later than some sea cucumber species (*Holothuria scabra* and *Stichopus japonicus*), which mature within 1-2 years.

Size at maturity for *C. frondosa* in SWNB has not been determined. However, the size of maturity for *C. frondosa* was determined to be between 80 and 102 mm in the St. Lawrence estuary.

Recruitment rates and natural mortality of sea cucumber in SWNB remains unknown. Nothing was found in the literature that would provide a preliminary indication of what these might be.

The **stock structure** of *C. frondosa* (i.e., the relationship of individuals in this area to adjacent areas) is unknown.

Rationale for Assessment

Advice was requested by DFO Maritimes Fisheries and Aquaculture Management on the status of the SWNB Stage II Exploratory sea cucumber fishery, specifically:

- Assess the impact of the SWNB sea cucumber fishery on the sea cucumber population(s) in this area, taking into account any available commercial or survey information including:
 - Catch rates,
 - Morphometric data, and
 - Known life-history characteristics.
- Evaluate the by-catch of non-sea cucumber species in this fishery.
- Evaluate the impacts of this fishery on benthic habitat.

The Fishery

During 1999-2006, a Stage I Experimental sea cucumber fishery consisting of two license holders using variations of modified scallop/urchin gear was permitted in the LFA 36 portion of SWNB. The purpose of this experimental fishery was to test gear performance and market potential. In every year except 2002, the experimental sea cucumber fishery took place from January to March. In 2002, the fishery was extended until June. Since 1999, each license holder has been required to submit a dockside monitoring document and a DFO Sea Cucumber Science Log, including tow locations, catch, depth, and wave height.

In 2006, five zones were created around the areas of primary fishing effort (Figure 1). One of these zones, St. Andrews Harbour, was closed to the fishery as a possible research area. The other four zones were each assigned a total allowable catch for experimental fishing during the 2006 season (1010 t in The Passages and 120 t in each of the three remaining zones: Magaguadavic River, South Deer Island, and Upper Passamaquoddy Bay) based on the average annual landings during the previous five years.

Prior to the 2007 fishing season, the SWNB sea cucumber fishery was authorized by DFO to move from Stage I Experimental to Stage II Exploratory status. Science and monitoring requirements that were established in Stage I continued during 2007-2008, and TACs and fishing zones remained in place.

Since 1999, more than 80% of the catch (Table 1; figures 2-3) and 90% of the fishing effort (Figure 4) was in a single fishing zone known as 'The Passages'. Landings increased to a peak of approximately 1600 t in 2005 and have since remained around 1100 t, which may be a function of specified fishing zones and an overall TAC of 1370 t being implemented prior to the 2006 fishing season (Table 1). Effort peaked in 2005 and has remained at lower levels during 2006-2008 (Figure 4). In Upper Passamaquoddy Bay, South Deer Island, and Magaguadavic River, there has been little effort (8, 87, and 19 hrs respectively) due to winter ice cover and poor weather conditions.

Table 1. Sea cucumber landings (t) by year and fishing zone as reported in dockside monitoring documents. TACs were implemented in 2006 and are included in parentheses.

Year	Zone						Total
	Magaguadavic River	The Passages	St. Andrews Harbour	South Deer Island	Upper Passamaquoddy Bay	Area Outside of Zones	
1999							
2000							651 651
2001		465					172 637
2002		725					72 797
2003		802					49 851
2004		1142					62 1204
2005	8	1410		40			200 1657
2006	35 (120)	926 (1010)		61 (120)		99 (120)	1122 (1370)
2007		1002 (1010)		29 (120)		36 (120)	1067 (1370)
2008	2 (120)	975 (1010)		32 (120)		65 (120)	1074 (1370)
Total	45	7636		163		1438	9281

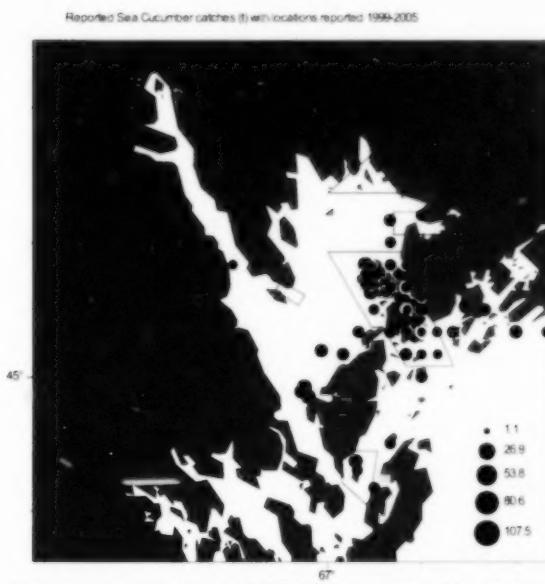


Figure 2. Location of SWNB sea cucumber fishery 1999-2005.

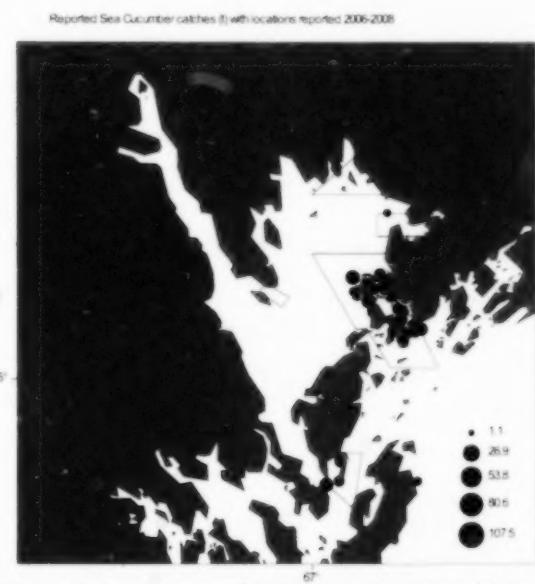


Figure 3. Location of SWNB sea cucumber fishery 2006-2008.

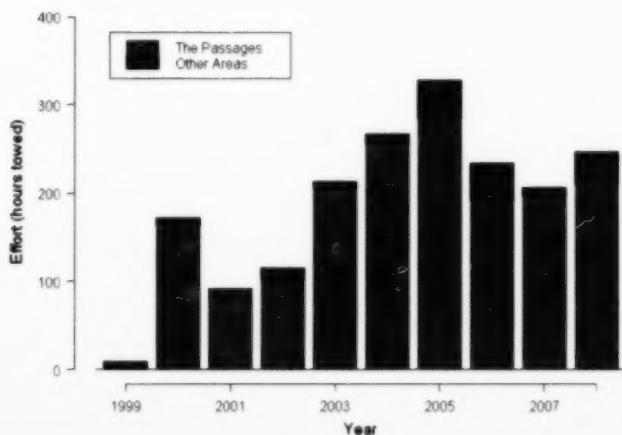


Figure 4. Effort directed towards sea cucumber in the SWNB fishery.

ASSESSMENT

Abundance and Distribution

There has been only one survey of sea cucumber in SWNB (conducted in 2004) and, as a result, catch rates in the fishery provide the only potential metric of sea cucumber abundance over time.

Fishery catch rates were calculated using the number of totes (approximately 70 L plastic boxes in which captured sea cucumbers are stowed during fishing activities) caught per hour of towing as reported in the Sea Cucumber Science logs. For all SWNB fishing areas combined, catch per unit effort (CPUE) peaked at 4877 kg/hr (71.7 totes/hr) in 2002 and has remained at similar levels since this time (Figure 5). Catch rates in 2007 and 2008 were similar to the long term average of

4292 kg/hr (63 totes/hr). In The Passages, catch rates during 2007 and 2008 were also near or above the zone average of 4434 kg/hr (65 totes/hr). Low effort in Upper Passamaquoddy Bay, South Deer Island, and Magaguadavic River makes annual variation in CPUE in these zones difficult to interpret.

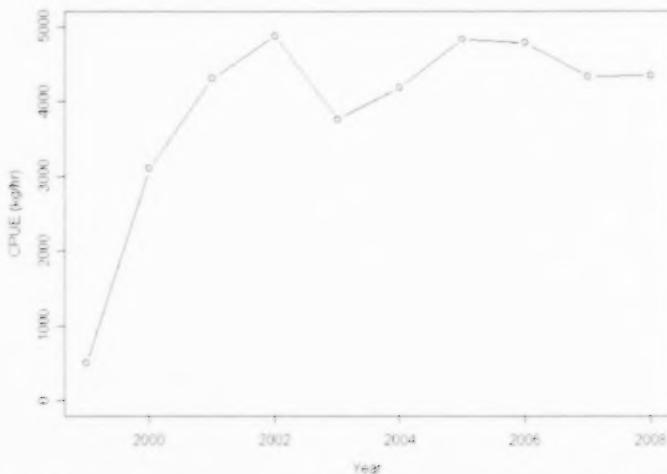


Figure 5. CPUE for sea cucumber in all fishing areas within the SWNB fishery.

A survey was conducted 27-29 July 2004 aboard the *F/V Sue & Ken* to determine catch rates and relative abundance of sea cucumber in the Passamaquoddy Bay area. The survey covered known areas of high sea cucumber abundance and explored some areas not previously fished by the licence holders. A total of 112 tows were completed using a 2.4 m drag. Each tow was 2-5 minutes in duration depending on bottom hardness. At the end of each tow, the number of totes of sea cucumber captured was recorded. The number of sea cucumbers per tote was determined for six totes approximately six hours after capture and the mean (245 sea cucumbers per tote) was used to prorate the catch from number of totes to number of sea cucumbers in a standard 200 m tow length.

Sea cucumber catches varied throughout the survey area from 0 to 4900 animals. Large aggregations of sea cucumbers were relatively localized (Figure 6). Highest catches (> 8 totes/tow) were found in the northern area of Deer Island where the majority of the 2000-2004 fishing effort was directed. Other areas of high sea cucumber densities were recorded in the northern area of Passamaquoddy Bay, an area that had not received experimental fishing effort, and in St. Andrews Harbour, an area which had received minimal fishing effort.

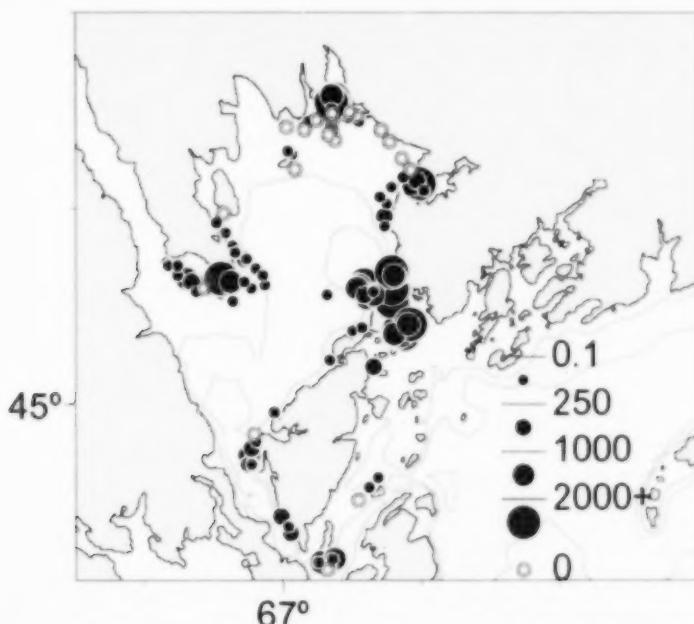


Figure 6. Number of sea cucumber caught per standard tow during July 2004 survey.

Maximum densities found were 4900 individuals per tow, which translates into roughly 10 sea cucumbers per m^2 (using a standardized tow area of 492 m^2). This is comparable to the densities determined by Singh et al. (2001) of 5-15 individuals per square metre, though they did identify local densities of up to 50 individuals per m^2 in Passamaquoddy Bay. Given that the standardized tow area was small (492 m^2), a catch of two totes (> 500 sea cucumbers) was considered commercially viable. Because of the patchy nature of sea cucumber distribution and the lack of a systematic survey across the fishing area, it is not possible to establish a total population abundance estimate at this time.

Size Composition

As of 2004, license conditions required a sample of 20 randomly selected sea cucumbers to be taken from one tow each fishing day for size measurements. During experimental fishing, 52, 85, 71, 57, and 84 daily samples were collected in 2004, 2005, 2006, 2007, and 2008, respectively. The variables measured were: contracted length, contracted wet weight, circumference, body wall thickness, meat weight, body wall weight, and viscera weight.

Standard measuring procedures were employed, but because sea cucumbers are comprised of 80-90% water and are able to swell and contract, there was considerable variability in the data. Nonetheless, there was an indication of a decrease in the size of animals landed over time (Table 2) that merits additional investigation. In the Bay of Fundy, protein content in the body wall has been reported to increase during the feeding period (suggesting that *C. frondosa* has the ability to accumulate energy reserves in the body wall) and this may explain some of the annual variation in size measurements. In addition, samples were derived from different areas, potentially of varying depth, which may also attribute to variation.

Table 2. Summary (mean ± standard deviation) of morphometric data from all areas for 2004-2008.

Year	Trait								Number of Animals
	Length (mm)	Wet Weight (g)	Circumference (mm)	Body Wall Thickness (mm)	Meat Weight (g)	Body Wall Weight (g)	Viscera Weight (g)		
2004	163.6 ± 28.9	255.6 ± 92.2	126.0 ± 14.7	3.1 ± 0.8	22.9 ± 7.5				1040
2005	156.4 ± 36.5	235.6 ± 78.0	124.2 ± 20.6	2.9 ± 0.8	21.1 ± 7.6				1699
2006	169.5 ± 31.2	208.3 ± 71.4	125.0 ± 15.5	2.6 ± 0.7	18.6 ± 5.4	55.6 ± 16.9	41.1 ± 18.0		1420
2007	158.2 ± 30.8	236.2 ± 69.9	128.1 ± 15.7	1.9 ± 0.6	17.6 ± 4.8	53.0 ± 14.2			1140
2008	154.6 ± 37.7	225.2 ± 84.2	123.9 ± 24.3	1.8 ± 0.9	18.6 ± 7.0	52.3 ± 17.5	46.5 ± 21.2		1660

Ecosystem Impacts

By-catch

During experimental and exploratory fishing activities, by-catch is recorded in a Sea Cucumber Science Log at each fishing location. During 1999-2005 experimental fishing, eleven different by-catch items (including shells and rocks) were reported. Sea urchins were the largest component of by-catch in all zones. Other reported by-catch organisms included: seastars, crabs, sea scallop (*Placopecten magellanicus*), Iceland scallop (*Chlamys islandica*), lobster (*Homarus americanus*), and octopus. In each zone, the tows that reported no by-catch ranged from 54% in St. Andrews Harbour to 86% in The Passages. Instances where no by-catch was reported can be interpreted in two ways, either there was no by-catch for those tows or there was by-catch but it was not recorded. Time constraints did not permit a similarly detailed analysis of the by-catch reported in science logs during 2006-2008, although we can report that the following species were observed: sea urchin, scallop, sea stars, lobster, mussels, and shells.

DFO certified at-sea observers monitored the sea cucumber fishery during eight exploratory fishing trips in 2008. These trips monitored a total of 280 fishing sets during the fishery. Of the 280 sets, 273 were located in The Passages, 5 in Magaguadavic River, and 2 in Upper Passamaquoddy. At-sea observers recorded a total of 10 species captured in the SWNB sea cucumber fishery (Table 3). Sea cucumber was the most abundant species by weight. Sea urchin was the most significant by-catch species by weight and represented approximately 3% of the sea cucumber catch. Prorating the observed catch to total landings reported during the 2008 fishery, it is estimated that up to 34 t of sea urchin may have been encountered as by-catch. However, because the observer protocols dictate that sets containing a small quantity (< 1 kg) of a species be recorded as 1 kg, the weights presented are likely to be an overestimate of the catches of by-catch species within the fishery. This is particularly true for some of the smaller-bodied species (e.g., toad crab, hermit crab, sea potato, and sea stars).

Table 3. Catch and by-catch as determined by at-sea observers deployed during eight trips in the SWNB sea cucumber fishery during 2008. Adjusted catch is the observed catch prorated to total landings for the 2008 season. Because observer protocols dictate that sets containing a small quantity (< 1 kg) of a species be recorded as 1 kg, observed catch and adjusted catch values presented are likely overestimates of the catches of by-catch species within the fishery.

Species	Observed Catch (kg)	Adjusted Catch (t)	% By-catch	% Sets with Species Present
Sea cucumber	116498	1059.0		99.6
Sea urchin	3810	34.5	3.26	99.3
Sea star	1331	12.0	1.14	100.0
Sea potato	1308	11.9	1.12	100.0
Toad crab	280	2.5	0.24	100.0
Hermit crab	167	1.5	0.14	59.6
Sculpin	113	1.0	0.10	40.1
Rock crab	87	0.8	0.08	31.1
Winter flounder	3	< 0.1	0.00	1.1
Lobster	3	< 0.1	0.00	1.1

In The Passages, sea cucumber, sea potato, toad crab, sea star, and sea urchin were caught in all sets. Winter flounder (*Pseudopleuronectes americanus*) and lobster were caught in approximately 1% of sets. Hermit crab, sculpin, and rock crab were caught in 59%, 41%, and 32% of sets, respectively. There were few observed sets in Magaguadavic River and Upper Passamaquoddy, although sea potato, toad crab, hermit crab and sea star were caught in all sets suggesting that these species may be common in these areas. Sea urchins were not observed in either of the two sets in Upper Passamaquoddy but were observed in all sets in Magaguadavic River.

The sea cucumber fishery returns all species other than sea cucumber to the water. At-sea Observers did not assess the condition of by-catch species; thus, survival of by-catch returned to the water is unknown.

Habitat Impacts

Description of the Area in Passamaquoddy Bay Where the Sea Cucumber Fishery has Occurred

Geomorphology, along with large tidal range, results in the generation of very high surface current velocities in portions of the area where the sea cucumber fishery has occurred, particularly within The Passages. Subtidal bedrock may be covered by boulders, gravel, sand, mud and shell hash. Sand and mud occurs in sheltered areas where the current is decreased and sedimentation occurs. Hard substrates (i.e., bedrock, boulder, gravel and shell hash) occur in shallow and deep areas experiencing high currents. A diverse benthic community carpets the rocky substrate, particularly in the deeper channels with high currents (HMSC 2008) where the encrusting crustose coralline algae are replaced by communities of brachiopod (*Terebratulina septentrionalis*) and a large biomass of suspension feeders. The highly diverse and abundant faunal community includes branching bryozoans, annelids, molluscs, crustaceans, echinoderms, and tunicates. Cnidarians (hydroids), soft corals, and anemones are common on steep cliff faces. In moderate to strong currents, a rich and diverse fauna of sponges occur. Most sponges are of the encrusting type, followed by those having a massive and upright morphology.

Potential Benthic Impacts of Sea Cucumber Fishing

Monitoring area swept over time is important as this measure may provide a potential indicator of benthic habitat impacts and may also be an early indicator of stock depletion given that fishery catch rates can sometimes be maintained by increasing the area fished. An analysis of area

swept during the SWNB sea cucumber fishery revealed that the area towed for all track lines ranged from approximately 3 to 5 km² per year. Because the area of overlap among track lines was not estimated, this represents an overestimate of the actual area impacted by the fishery. The fishery occurs almost entirely in The Passages, it is noted that no more than 10% per year of the area of this zone was swept by a sea cucumber drag, and a portion of this area could have been swept multiple times per year. Note that the total area of The Passages used in these calculations includes intertidal areas that are not likely to be dragged during the fishery.

Mobile bottom-contacting fishing gear, such as that used in the sea cucumber fishery, can alter or damage physical features of the seafloor, as well as benthic populations and communities. The by-catch recorded for the SWNB fishery includes sea urchins, sea stars, sea potatoes, and crabs and, given the high biodiversity of The Passages, it can be assumed that the many epifaunal upright and encrusting organisms smaller than that retained by the gear are encountered. Impacts to organisms such as sponges and tunicates that are dislodged, torn, scraped or overturned during fishing activities may not be adequately documented by examining by-catch, although it may be assumed that such structurally fragile species would be negatively impacted by the gear. Sublethal effects (i.e., injury and exposure) may increase the vulnerability of these individuals to other sources of mortality or lower their fitness. Mobile bottom-contacting fishing gear is considered to be among the most destructive gear types in terms of habitat change. Drags affect the seafloor community structure, reducing benthic biomass, biodiversity, and habitat complexity, and have ecosystem-level impacts on productivity and nutrient cycling.

As part of a depletion study conducted in 2006, 76 tows were completed over the same narrow strip of bottom in the main channel of St. Andrews Harbour over four fishing days. Following the fishing activity, eight transects were run perpendicular to the drag path 2 days after the study using towed video equipment. Sea cucumbers were patchily distributed and seen as highly aggregated clusters, frequently associated with larger rocks or boulders on a gravel or sand/silt bottom. Drag marks were clearly visible on sandy/silt bottom areas as indicated by scrape marks about 5-10 cm deep where the drag removed sea urchins, sea cucumbers, and a lush periphyton layer on the surface of the sediment. The periphyton layer (probably diatoms and other microalgae) is very common in the channel and sea urchins appear to feed from it (as indicated by clear patches or 'feeding trails' extending out behind individual urchins). The recovery time for the periphyton following dragging events is not known. Drag marks on harder rock or gravel surfaces were more difficult to distinguish but could be seen as disturbed rocks or scrape marks on rocks.

Sources of Uncertainty

Population structure is unknown, including source of recruits and the extent of movement among areas. Industry participants indicated that large numbers of small sea cucumbers have been observed recently in their catch.

There is no directed survey for sea cucumber and a fishery-independent abundance estimate is lacking.

A reliable estimate of sea cucumber catchability is unavailable for use in estimating exploitation.

Productivity, size at maturity, sustainable exploitation rates, and other reference points are all unknown.

Survival of by-catch returned to the water has not been evaluated for this fishery.

The consequences of removals on ecosystem structure and function are unknown, particularly with respect to longer-term benthic community and biodiversity implications and related rates of recovery.

CONCLUSIONS AND ADVICE

Indicators of status of sea cucumbers within the area of interest are limited. While catch rates have been maintained over time, there are uncertainties in whether catch rates in this fishery are reflective of population abundance. There was an indication of a decrease in the size of animals landed over time, although the significance of these results has not been established and additional investigation is warranted. If the size of animals landed has decreased over time, this would result in an increase in the exploitation rate associated with the TAC of 1370 t. Research would be required to determine whether reductions in size were a result of changes in environmental conditions, fishing patterns (e.g., fishing in deeper waters) or as an effect of fishing on the population.

The predominant by-catch species in the SWNB sea cucumber fishery was sea urchin with catches estimated at 34 t during 2008. By comparison, 1028 t of sea urchin was landed in LFA 36 during the directed fishery in 2007-2008. At-sea observers provided more detailed descriptions of by-catch than was recorded in sea cucumber science logs and continued at-sea observer coverage is recommended.

The environment in which the SWNB sea cucumber fishery is conducted is considered to be productive and diverse, with very patchy distribution of benthic organisms and features. Immediate, localized impacts of the sea cucumber fishing gear on benthic habitat were observed (e.g., disturbance of periphyton layer), but the longer-term community implications and rates of recovery are not known and are worthy of further investigation. This is consistent with advice provided previously by DFO Science on this type of gear (DFO 2006b). Risks of habitat impacts within the current fishing areas could be reduced by investigating the location/extent of any particularly sensitive habitat features and investigating the rates of recovery for known habitat types within these areas. Additional studies conducted before expansion of fishing activity beyond the existing zones may reduce risk of potential habitat and biodiversity impacts. Studies could include benthic habitat mapping, mapping of other local fishing activities that use mobile bottom-contacting gear, and development of indicators of impact (e.g., area of impact by habitat type, or related to recovery rates).

Given the number of uncertainties associated with this fishery, a cautious approach is advised.

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FOR MORE INFORMATION

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ISSN 1919-5079 (Printed)
ISSN 1919-5087 (Online)

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CORRECT CITATION FOR THIS PUBLICATION

DFO. 2009. Southwest New Brunswick Sea Cucumber (*Cucumaria frondosa*) Exploratory Fishery Assessment. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2009/014.

